AN INVESTIGATION OF THE DESTRUCTIVE EFFECT OF FLOTATION TIRES

ON

FLEXIBLE PAVEMENT

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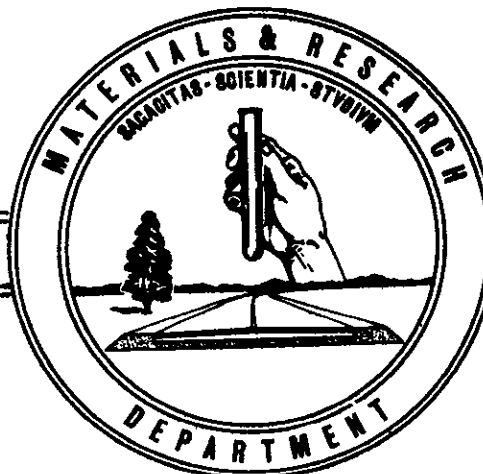
Ernest Zube* and Raymond Forsyth**

SYNOPSIS

As a result of the increased usage of flotation or
"wide base" tires in lieu of the normal dual wheel con-
figuration during the last three years, an investigation
has been completed to compare the relative destructive
effect or to determine the single axle loading which
would produce the same destructive effect as that re-
sulting from the dual wheel single axle legal loading of
18,000 pounds. The two criteria of destructive effect
selected for this investigation were pavement deflection
and strain.

Deflection measurements were made using linear vari-
able differential transformer gage installations and the
Benkelman beam. Pavement strain measurements were made
using SR4 strain gages attached to the top and bottom of
the AC surfacing. Test sites with widely varying
structural sections were selected for this study. Analy-
sis of strain and deflection data indicates that the

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destructive effect of a flotation tire with a single axle loading of 12,000 pounds equals or exceeds that of the dual wheel configuration at an axle loading of 18,000 pounds.

Relationships between tire pressure, pavement temperature, axle loading, pavement deflection, surface tensile strain, and type of wheel loading are presented.

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INTRODUCTION

In the last two years, the use of flotation or "wide base" tires in lieu of the normal dual wheel configuration has become increasingly commonplace, particularly on transit mix concrete trucks. The reasons advanced by the tire manufacturers for the increased popularity of these tires include: (1) lower rolling resistance, (2) reduced dead weight, (3) improved riding qualities, (4) off the road mobility, and (5) a high load front axle capacity. With the increased usage of these tires, it was apparent that a comparison should be made of the destructive effect of trucks utilizing this type tire with that induced by the normal single axle dual wheel configuration at its maximum legal load limit of 18,000 pounds.

An investigation of a similar nature was included and reported on during the AASHO road test (1). In this investigation various test sections of Loop 2 were subjected to 32,000 pounds tandem axle loads with conventional

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and low pressure-low silhouette (LPLS) tires. The results
of this study indicated that loss of pavement service-
ability was slightly less over those sections on which the
LPLS tires were utilized. However, it is believed that
these results are not significant to this investigation
since the tires involved were of a military type. An
examination of the contact prints shown by Figure 9
(page 11) of the final report (1) reveals an entirely
different dual and flotation tire configuration than that
resulting from standard commercial truck tires of both
types. In fact, the over-all width of the two military
duals is equal to or less than that of the military LPLS
tire. The reverse holds true in the case of the commercial
flotation and dual truck tires used in this investigation.

CRITERIA OF DESTRUCTIVE EFFECT

The first and most important decision to be made for
a comparison of the destructive effects of two types of
truck tire configuration is the selection of criteria
upon which rational judgments may be based. Certainly
destructive effect of wheel loads on flexible pavements
may be evaluated in many different ways. In this particu-
lar case, however, the difference between the wheel
configurations are relatively minor so that a valid
appraisal requires sensitive criteria. In addition, it
is necessary that these criteria be related to flexible

pavement performance. It is believed these requirements
are effectively fulfilled by measurements of AC surfacing
tensile strain and transient pavement deflection.

The choice of AC surfacing tensile strain was based
on the preliminary findings of Pell (2) and others, who
observed that the fatigue life of an AC surfacing is pri-
marily a function of tensile strain and independent of
surfacing temperature or speed of loading. Application
of the layer theory and the limited data available indi-
cates that tensile strain at the bottom of the AC sur-
facing is substantially greater than that which occurs
on the surface.

Unfortunately, the time available for this investi-
gation did not permit the installation of strain gages at
the bottom of the AC surfacing except for the one project
installation at the Shell Avenue test road. It is
reasonable to assume, however, that surface tensile strain
measurements, if not as large in an absolute sense as the
bottom strain measurements, are at least directly pro-
portional so that for the purpose of comparison they may
be considered as valid criteria.

The selection of pavement deflection was made with
considerable confidence in view of the amounts of very
productive pavement deflection research of the last twenty
years. In addition to the extensive deflection work done
on the two major test roads (AASHO and WASHO), the State

of California and other agencies have, with some success,
related allowable levels of transient pavement deflection
to fatigue cracking of AC surfacing. The California
Division of Highways has, in fact, for some years uti-
lized deflection measurements in the design of recon-
struction of distressed roadways. There can be little
doubt that transient pavement deflection provides an
excellent indicator of the in-place strength of an
existing roadway and a reasonably accurate forecast of
future fatigue cracking.

Considerations of plastic deformation or lateral
displacement have not been taken into consideration
since, as will be shown in a subsequent section of this
report, for a given axle load the pressures induced by
both wheel configurations at depths greater than 6
inches are, for all practical purposes, the same.

TEST EQUIPMENT AND INSTRUMENTATION

This study, undertaken in April, 1963, was ac-
complished using pavement deflection and strain measure-
ments taken over several different structural sections
in Northern California. Two trucks, both with single
rear axles, were used as test vehicles. In one case,
the axle was loaded to California's legal limit of 18,000
pounds and supported with dual wheels using 10.00-20
truck tires with the 12 ply casings inflated to a pressure
of 70 psi. The rear axle of the other truck carried a

variable load and was supported by 18.00-19.5 flotation tires with the 16 ply, wide base casings inflated to 75 psi (see Figure 1).

Pavement deflection measurements were obtained with a Benkelman beam and, at three locations, with linear variable differential transformer (LVDT) gages. Strain measurements were taken at varying distances from the outside edge of the loaded tires utilizing surface set SR-4 strain gages attached to the pavement surface (see Figures 2 and 3). At one test section, the Shell Avenue test road in Martinez, prior instrumentation, in support of the test road project sponsored jointly by the University of California and Contra Costa County, made it possible to obtain pavement strain measurements at the bottom of the AC surfacing layer.

After grinding the surface to remove large irregularities, two transversely oriented SR-4 strain gages were placed at each test location. These gages, placed at 6" intervals, were cemented into place with "Duco" cement and then covered with "Gagekoat No. 5" for physical protection. During the early trials, it was noted that actual contact between the strain gage and the tire resulted in extremely erratic and obviously incorrect readings. Since unprotected gages were prone to damage by tire contact, it was found necessary to provide this protective coating.

TEST SECTIONS

It was apparent from the beginning of the investigation that a study involving the variables of load, tire configuration, structural section, pavement deflection, and pavement strain could, unless limited in scope, become extremely unwieldy, time-consuming, and expensive. The relatively few test sections were chosen, therefore, to represent the most common types of AC surfaced structural sections, and in addition, to present a large range of pavement deflection for increased sensitivity. The sites selected for this study were:

Location	Structural Section
Service & Supply Yard 60th & Folsom Blvd. Sacramento, Calif.	3" Asphalt Concrete 10" Aggregate Base
Warehouse Road (60th & Folsom Blvd.) Sacramento, Calif.	1-1/2" to 2" Asphalt Concrete 9" Aggregate Base
Pendegast St. Woodland, Calif.	2" Asphalt Concrete 6" Aggregate Base
Shell Avenue Martinez, Calif.	3" Asphalt Concrete (New) 2" Asphalt Concrete (Old) Variable Aggregate Base
State Fair Grounds Sacramento, Calif.	2" Asphalt Concrete 5" Aggregate Base
III-Sac-232-A Sta. 304+04	3-3/4" Asphalt Concrete 8" Cement Treated Base
III-Sac-232-A Sta. 405+90	6-3/4" Asphalt Concrete 6" Aggregate Base
III-Sac-232-A Sta. 354+00	3-3/4" Asphalt Concrete 12" Aggregate Base

The initial range of flotation tire loading was de-
termined by utilizing the theoretical Boussinesq equation.
With this analysis, a comparison of vertical pressure in-
duced by twin circular disks at 75 psi carrying a gross
weight of 9000# was compared to that induced by a single
circular disk at 75 psi loaded from 5000# to 6000#. The
results of this analysis, shown by Figure 4, correspond
to calculations made earlier by personnel of the Washington
State Highway Department. Examination of Figure 4 shows
that at depths of from 0" to 6", the vertical pressure in-
duced by the single circular disk would exceed that of the
twin circular disks. Beyond approximately 11" the vertical
pressure induced by the twin disks exceeds that of the
single circular disk. Although the Boussinesq equation
is purely a mathematical development of the elastic theory
for an isotropic, elastic, homogenous, and infinite mass,
it has been shown to be reasonably accurate for flexible
sections as demonstrated by Investigators Herner (3) and
Sowers (4) and the results by the Stockton test track (5).
It was decided, based upon this analysis, that a single
flotation tire loading range of 5000# to 6000# would pro-
vide a good starting point for the comparison of the two
types of tire and wheel configuration.

It was also decided to confine both deflection and
pavement strain measurements to the axis normal to the
direction of travel at each test point. This selection

is based upon long experience in California in which it has often been observed that the initial manifestation of alligator cracking is, in almost every case, longitudinal cracking in or close to the wheel path. The fact that transverse bending is generally more pronounced is obvious from examination of deflection contour maps resulting from the WASHO (6) and AASHO (7) test roads. The test program for each test section, therefore, consisted of applying SR-4 strain gages oriented transversely and, upon completion of instrumentation, the measurement of pavement surface strain at varying distances from the edge of the loaded wheel. At each location, strain gage measurements were determined for a dual wheel loading of 9,000 pounds and single flotation tire loaded at 5,000, 5,500, and 6,000 pounds. Where these installations were available, LVDT deflection measurements were also obtained for the aforementioned wheel loadings. At those locations where LVDT gages were not available, however, Benkelman beam deflection measurements were obtained.

During the final phase of the investigation, a series of surface strain and LVDT deflection measurements were obtained at a roadway immediately in front of the Women's Building of the California State Fair Grounds. This site offered advantages not available elsewhere, which included (1) complete freedom from traffic interference, (2) a high range of pavement deflection,

(3) availability of electric power for instrumentation,
and (4) close proximity to the Headquarters Laboratory.
Because of these advantages, a more comprehensive instru-
mentation was accomplished and the scope of the investi-
gation increased to study the effects of two more variables.
These were (1) a wider range of flotation tire single axle
loadings, and (2) the effect on pavement deflection and
surface tensile strain of lowered flotation tire pressures.

ANALYSIS OF DATA

During the first few trials it was observed that even
relatively minor variations in pavement surface temperature
resulted in very significant differences in the strain
measurement induced by a given wheel load. Because the
principal objective of this program was a comparison of
destructive effect induced by two different vehicles with
differing wheel configurations and loadings, it became
apparent that the variable of pavement surface temperature
had to be eliminated or minimized. This was accomplished
by continuously alternating the two different trucks during
every test series. Thus, for each balloon tire strain
measurement, a corresponding dual wheel measurement was
obtained to provide the basis of the comparison (see
Figure 5).

The effect of variations in temperature on surface
tensile strain is shown by Figure 6, which is a plot of

surface strain versus distance to edge of loaded tire for
three different pavement temperatures at one test location.
Examination of these plots reveals that maximum tensile
strain for the dual wheel configuration varied from 460 to
585 microinches per inch. These plots also show the very
definite reversal of a surface stress from tension to com-
pression, which generally occurs at from 2" to 5" from the
edge of the loaded wheel.

Another interesting aspect of Figure 6 is that maxi-
mum tensile strain occurred, for this gage installation,
at the middle pavement temperature (73^OF) with the strains
at 63^OF and 101^OF being about equal. This may indicate
the existence of an optimum value of pavement temperature
for a given AC surfacing insofar as surface strain is con-
cerned. It is possible that increased cohesion at low
temperatures and strain attenuation over a relatively
large area due to plastic flow at high temperatures results
in low strains at temperature extremes.

Over the cement treated base section on III-Sac-232-A,
the data did not reveal any "peaking out" of tensile strain.
It is possible that inability to attain the critical
distance to the edge of the tire due to the strain gage
insulation precluded the determination of this peak value.
This section, however, produced extremely low strain values
so that there is some doubt as to the relative importance
of this section to the study.

The relationship between strains induced by both wheel configurations for all sections revealed a very noticeable lack of consistency insofar as type of structural section is concerned. This is shown by the relatively weak structural section of Pendegast Street in the City of Woodland. Here, it was found that the equivalent flotation tire axle loading, insofar as destructive effect was concerned, was 12,300 pounds as compared to the 11,000 pounds equivalency for the cement treated base overlay section at El Centro Road. Further examination of the data revealed that relative surface tensile strain is more directly relatable to pavement temperature than structural section. This is shown by Figure 7, a plot of the ratio of surface tensile strain induced by 11,000 and 12,000 pound flotation tire axle loadings, and an 18,000 pound dual wheel single axle loading versus pavement temperature. A relatively good correlation exists for the ratio involving a flotation tire axle loading of 12,000 pounds and pavement temperature. The beginning of a trend is also apparent for the 11,000 pound flotation tire axle loading. These data would indicate that, regardless of the structural section, the surface tensile strain induced by the flotation tire with a 12,000 pound single axle loading is equivalent to a dual wheel axle loading of 18,000 pounds at a pavement temperature of approximately 80°F. At lower temperatures

the strain induced by the flotation tire is less and at

higher temperatures the strain is greater. This general

trend is also apparent for the flotation tire at an

11,000 pound axle loading, which is equivalent in surface

strain to the dual wheel loading at approximately 105°F.

Leaving relative strain and discussing absolute values

of surface tensile strain, Table 1 presents peak values of

surface tensile strains for varying flotation tire axle

loadings and the dual wheel loading at 18,000 pounds for

varying structural sections and temperatures. These data

show that the heavier structural sections tested on Road

III-Sac-232-A produce substantially lower surface tensile

strains than were obtained on the relatively weak sections

at the Shell Avenue test road, City of Woodland, and the

State of California Service and Supply yard. It is also

interesting to note that the maximum surface tensile

strains induced by the dual wheels did not occur at the

maximum test temperature at any of the test sections ex-

cept the asphalt treated base section on Road III-Sac-232-A.

A comparison at this location was somewhat difficult due

to the limited range of pavement temperature, however.

At the Shell Avenue test section, it was possible to

determine both transverse and longitudinal strain measure-

ments from the bottom of the surfacing. These results are

shown by Figures 8 and 9. Because the strain gage involved

was fully protected from direct approach of the loaded tire,

it was possible to determine the full range of tensile and
compressive strain measurements for the dual wheel con-
figuration with an axle load of 18,000 pounds and a
flotation tire single axle configuration loaded to 12,000
pounds. It was found that longitudinal strain is higher
at the bottom of this pavement than is the transverse
strain. Figure 8 reveals that the bottom transverse
strain of the flotation tire with an axle loading of
12,000 pounds is almost equal to that induced by the dual
tires. The bottom longitudinal strain induced by the
flotation tire (Figure 9), however, was well in excess
of that for the dual tires.

At three locations it was possible to compare pave-
ment deflection values for both balloon and dual wheels
with LVDT gage installations. The data from two of these
installations are presented graphically by Figures 10 and
15. On Figure 10, the transverse deflection profile ob-
tained at Shell Avenue reveals a higher maximum deflection
value for the flotation tire axle loaded to 12,000 pounds
(0.038") than the dual wheel axle configuration at 18,000
pounds (0.034").

At all three locations, however, the maximum value of
pavement deflection for the flotation tire with an axle
loading of 12,000 pounds exceeded that of the dual wheel
axle configuration loaded to 18,000 pounds. The flotation
tire axle loading at 11,000 pounds was less, however, than

that of the dual wheel axle configuration at 18,000 pounds.

A plot of flotation-dual tire deflection ratios for varying flotation tire loads is presented for two gage locations at the State Fair Grounds by Figure 11. This data is considered significant due to the very minor temperature differential during the test period. At both gage locations an equivalence in pavement deflection is attained at a flotation tire single axle loading of 12,200 pounds, which is in accordance with the earlier data.

Although it was impossible to compare maximum pavement deflections at those installations where LVDT gage installations were not available, the Benkelman beam data did provide an opportunity to compare the shapes of the transverse deflection profiles from the outside tire edge for each wheel configuration. These plots are shown by Figures 12 through 14. They indicate, in every case, a smaller area of influence and, hence, sharper bending of the pavement by the flotation tire.

As previously mentioned, a final portion of the program at the State Fair Grounds was devoted to a determination of the effect of lowered flotation tire pressures on transverse tensile strain and deflection. In addition to the strain and deflection measurements obtained at flotation tire single axle loadings of 10,000, 12,000, 15,000, and 18,000 pounds, additional data was obtained at the 12,000 and 18,000 pound flotation tire single axle loadings, for a

flotation tire pressure of 55 psi. This tire pressure was
selected as the minimum at which the flotation tires could
be operated without incurring tire damage. Deflection and
strain data resulting from the lowered flotation tire
pressures is presented by Figures 15 through 17. On
Figure 15 we note that pavement deflection at the flo-
tation tire single axle loading of 12,000 pounds was not
significantly reduced by lowering the tire pressure. At
the 18,000 pound flotation tire single axle loading, how-
ever, the lowered flotation tire pressure induces a 10%
reduction in pavement deflection. On Figures 16 and 17,
we find that lateral surface tensile strain was actually
increased by 13% at both the 12,000 and 18,000 pound flo-
tation tire single axle loadings, with a reduction in
flotation tire pressure. This phenomenon is apparently
the result of an increased pressure concentration at the
side walls due to the reduction of pressure. This con-
clusion tends to be borne out by the work of Freitag and
Green in a paper presented to the Highway Research Board
in January, 1962 (8). On Figure 4 of this report, vertical
stress contours under an 11.00-20, 12-ply smooth tire loaded
to 3,000 pounds are presented for three inflation pressures.
Here, side wall vertical stress remains relatively high
for all three inflation pressures, with interior vertical
stresses increasing in approximate proportion to increased
inflation pressure. It is interesting to note that maxi-
mum edge or side wall stress was attained at the median

inflation pressure rather than at the highest or design
inflation pressure. The data presented in the paper also
indicate that vertical stress is very much a function of
the construction or ply of the tire; i.e., the lower the
ply, the more closely the contact pressure approximates
air pressure. We may conclude, therefore, that a tangible
reduction in surface tensile strain through lowered air
pressure could be accomplished only by a tire specifically
designed for the lower pressure and as low a ply rating
as possible, consistent with the operational demands of
the truck.

<center>SUMMARY</center>

From April until November, 1963, an investigation
for the purpose of comparing the destructive effect of
wide base flotation tires and the standard dual wheel
configuration on pavement was completed by the Pavement
Section of the Materials and Research Laboratory. Transient
pavement deflection and surface tensile strain were selected
as the two criteria for evaluating destructive effect.
Pavement deflection and strain measurements were obtained
over eight roadways, representing a relatively wide range
of flexible and composite structural section. Sufficient
data was accumulated to evaluate the effect of pavement
temperature, single axle load, and tire inflation pressure
on pavement deflection and surface tensile strain. With
the cooperation of the University of California, it was

possible to obtain bottom longitudinal and transverse strain measurements at the Shell Avenue test road.

Analysis of the data resulting from this investigation indicates that:

1. Using maximum pavement deflection as a criteria, the destructive effect of a flotation tire with a single axle loading of 12,000 pounds equals or exceeds that of a dual wheel configuration at an axle loading of 18,000 pounds.

2. The relationship between the maximum transverse tensile surface strains induced by flotation tires at various axle loadings and the dual wheel at an 18,000 pound single axle loading relates directly to pavement temperature.

3. At a pavement temperature of 80°F, a 12,000 pound flotation tire axle loading is equivalent to the dual wheel axle configuration at 18,000 pounds. At lesser temperatures, balloon tire strains are lower and at higher temperatures are greater than those induced by the dual wheel configuration.

4. At 105°F, the flotation tire axle loading at 11,000 pounds is approximately equivalent to the dual wheel axle configuration at 18,000 pounds.

5. Absolute surface strain values are significantly greater for weaker structural sections for both wheel configurations than those resulting from relatively strong structural sections.

6. The data available indicates surface tensile strain is
   relatively low at extremes of temperature and approaches
   a definite peak at an intermediate temperature range.
   The temperature for peak tensile strain is probably a
   function of the type of structural section. This being
   the case, it is probable that even though the ratio of
   flotation-dual wheel strain increases with temperature,
   absolute values of strain for both types of wheel
   configuration decrease at higher temperatures.

7. At a flotation tire single axle loading of 18,000
   pounds, pavement deflection decreased by 10% with a
   reduction in inflation pressure from 75 to 55 psi. At
   a flotation tire single axle loading of 12,000 pounds,
   the reduction in deflection due to fluctuations of
   inflation pressures was not found to be significant.

8. Lateral surface tensile strain increased by 13% at
   both the 12,000 and 18,000 pound flotation tire single
   axle loadings with a reduction in tire pressure of
   from 75 to 55 psi. This is believed to be the result
   of a greater concentration of contact stress at the
   side walls resulting from a decrease in tire pressure.

CONCLUSION

Based upon the above, it may be concluded that a
standard flotation tire with a 12,000 pound single axle
loading is, insofar as relative destructive effect on a
flexible or composite pavement is concerned, the equal to

a standard dual wheel configuration with an 18,000 pound single axle loading. This equivalency, however, is subject to a certain degree of variation with pavement temperature. Also, it appears that variations in flotation tire pressure will have a beneficial effect on this equivalency only with an accompanying change in the tire structure. In terms of absolute destructive effect, both tire and wheel configurations induce greater destructive effect on a relatively thin or weak structural section than a thick or composite pavement section.

ACKNOWLEDGEMENTS

Table 1

Tabulation of Peak Values of Transverse Surface Tensile Strain

Location	Structural Section	Pav't Temp. (°F)	Flotation Tire Axle Loading (lbs)	Max. Surface Tensile Strain (Flotation) Micro in./in.	Max. Surface Tensile Strain (Dual Wheel) Micro in./in
III-Sac-232-A Sta. 304+04	3-3/4" AC	110°-118°	11,000	28*	36*
	8" CTB(Cl"A")	94°- 98°	12,000	48*	42*
	Exist. Pav't				
III-Sac-232-A Sta. 405+90	3-3/4" AC	93°- 94°	11,000	112	108
	3" AC (Base)	92°- 99°	11,000	170	185
	6" AB	85°- 90°	12,000	170	170
	Exist. Pav't	87°- 92°	12,000	175	163
III-Sac-232-A Sta. 354+00	3-3/4" AC	75°- 77°	10,000	90	125
	12" AB	130°-132°	12,000	62	49
	Exist. Pav't	68°- 71°	12,000	105	116
Service&Supply Yard (60th St. & Folsom Blvd)	3" AC	105°-115°	10,000	314	352
	9" AB	85°- 95°	11,000	257	277
		118°-128°	12,000	352	310
City of Woodland (Pendergast St.)	3" AC	100°-110°	10,000	385	468
	6" AB	70°- 75°	11,000	473	588
		61°- 64°	12,000	427	463
Shell Ave. Test Road Martinez	3" AC (New) 2" AC (Old) Var. AB	70°- 71°	12,000	795**	800**
StateFairGrounds (Women's Bldg.)	2" AC 4" AB				
Gage #1		40°- 42°	10,000	145	190
		42°	12,000	167	205
		46°	15,000	253	228
		43°- 46°	18,000	283	188
Gage #2		40°- 42°	10,000	80	122
		42°	12,000	100	125
		46°	15,000	148	140
		43°- 46°	18,000	160	119
Gage #3		40°- 42°	10,000	110	150
		42°	12,000	124	162
		46°	15,000	190	177
		43°- 46°	18,000	215	155
Gage #4		40°- 42°	10,000	110	158
		42°	12,000	135	167
		46°	15,000	205	198
			18,000	232	155

*Point of stress reversal not determined.
**Transverse tensile strain at bottom of AC layer.

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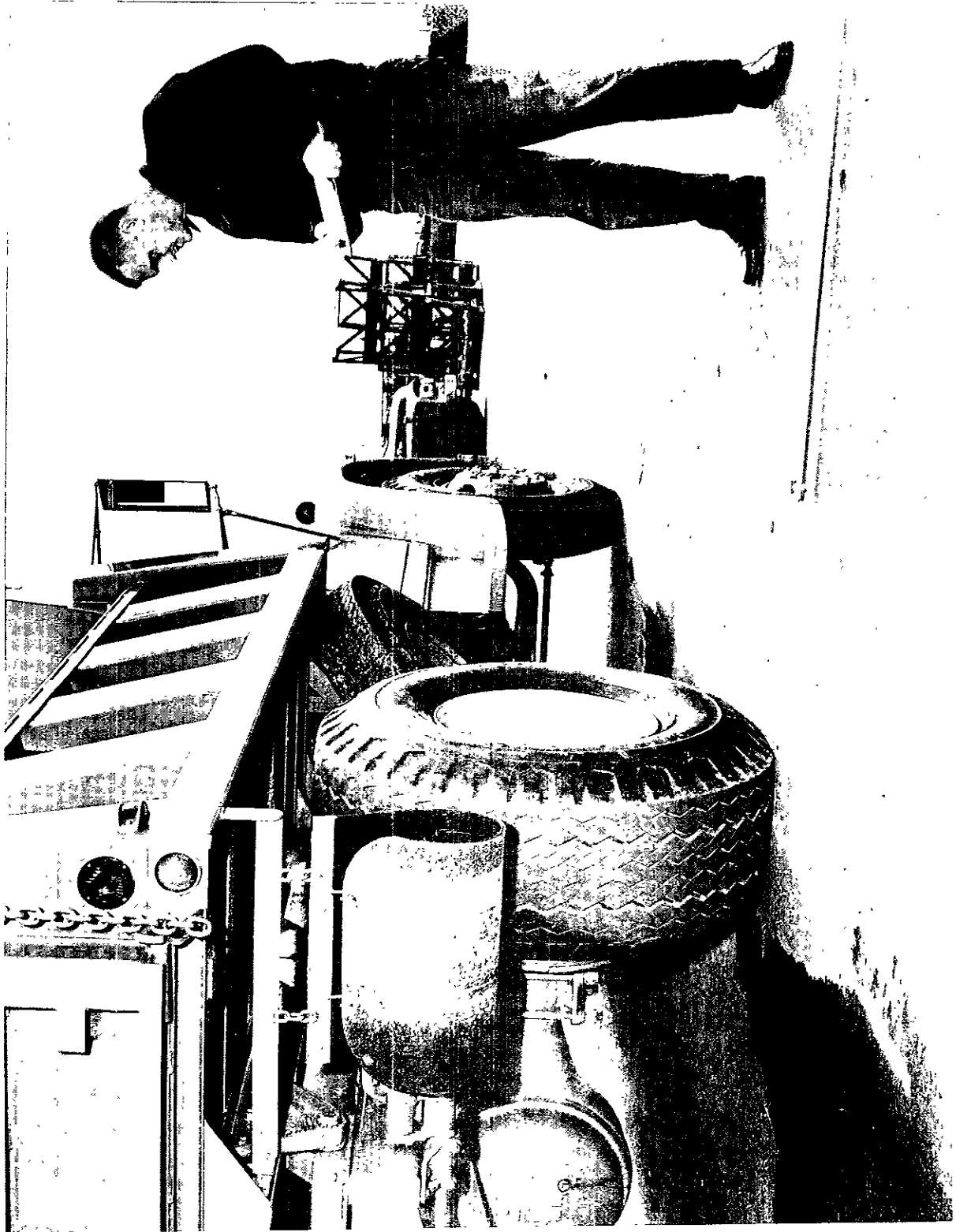
Figure 1

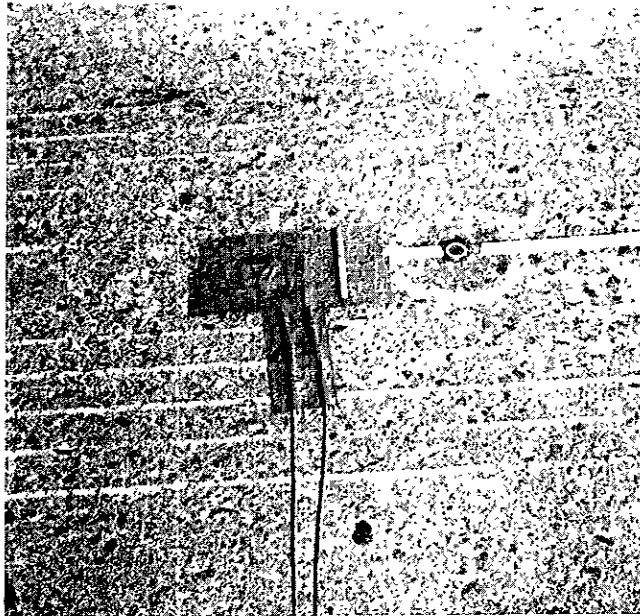Truck with Single Axle "Flotation" Tire Configuration

Figure 2

**SR-4 Pavement Strain and LVDT Deflection Gage
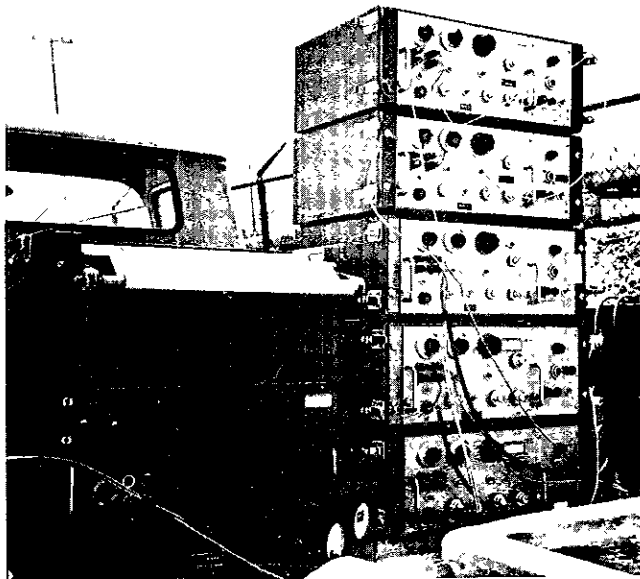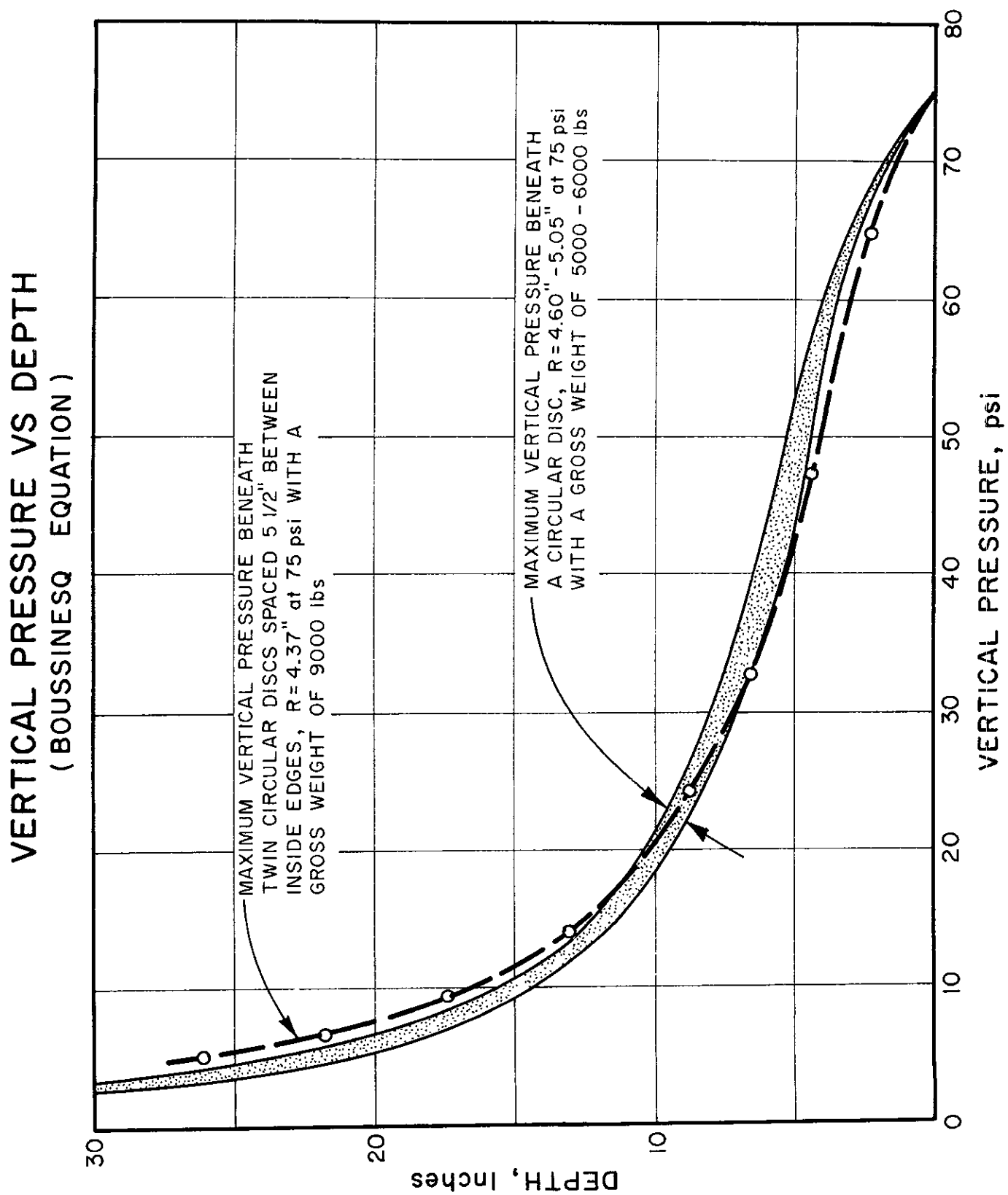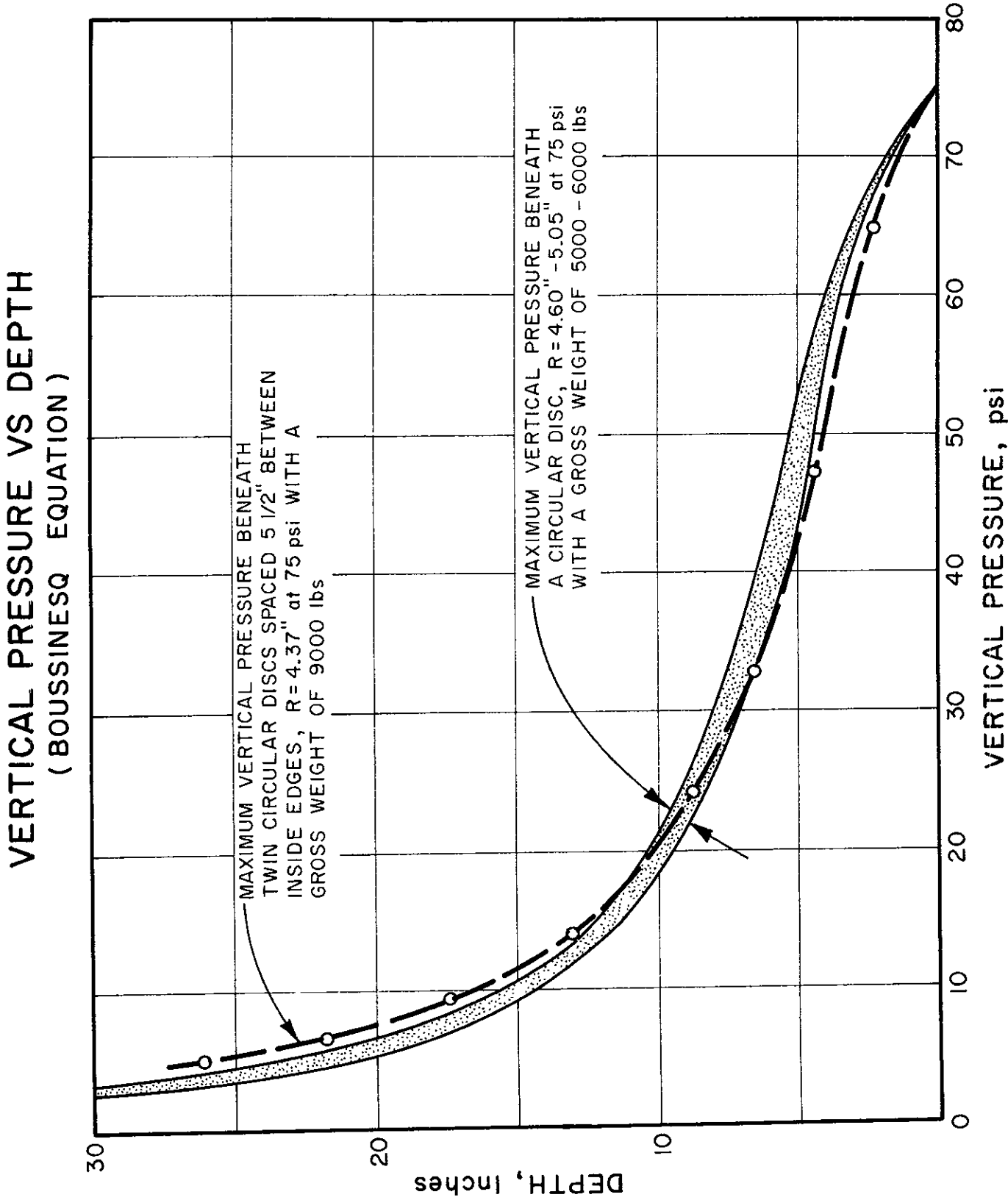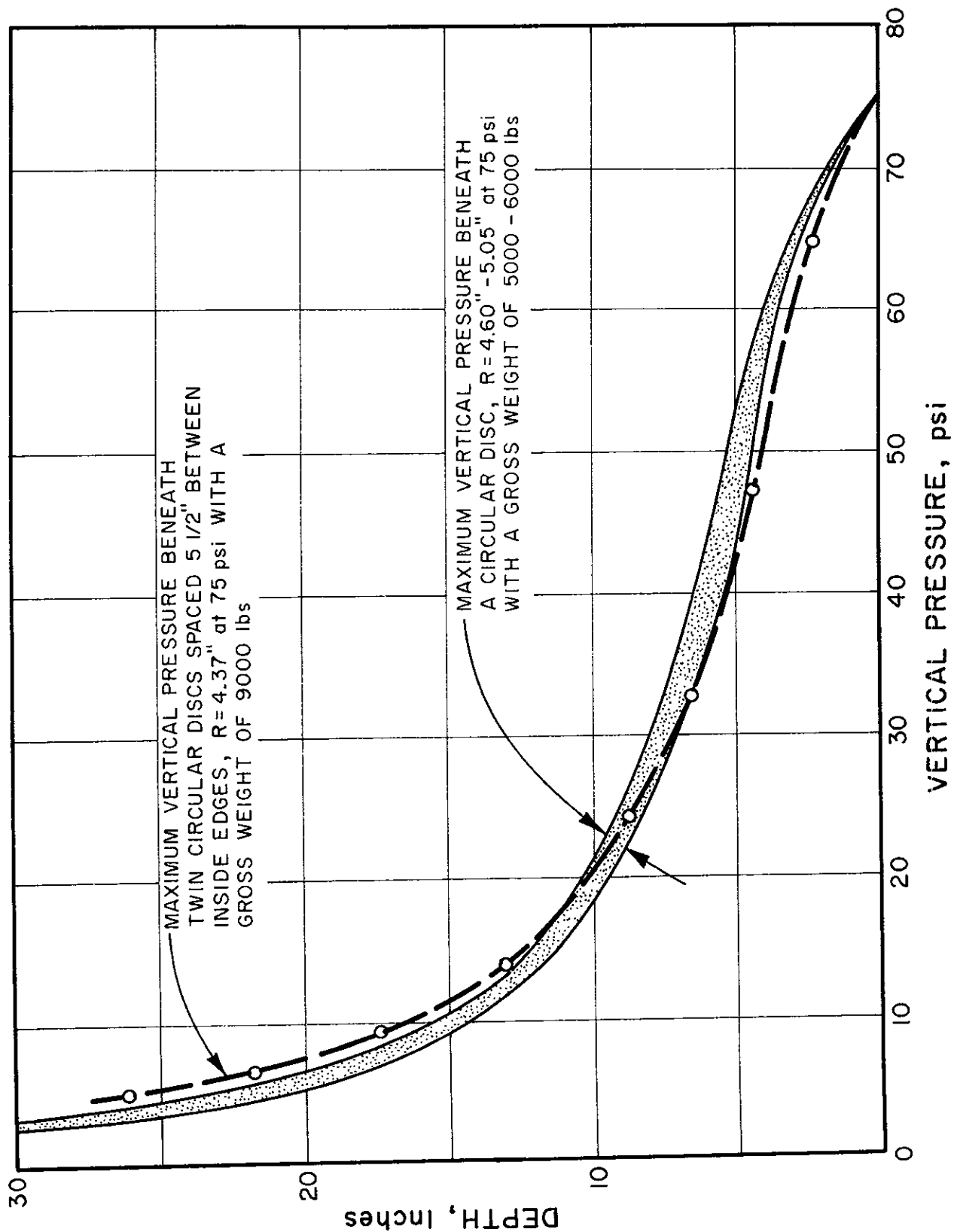Installations at Shell Ave. Test Road at Martinez.**

Figure 3
**Strain Recording Equipment Operated by Personnel
of the University of California at the Shell Ave.
Test Road.**

VERTICAL PRESSURE VS DEPTH
(BOUSSINESQ EQUATION)

MAXIMUM VERTICAL PRESSURE BENEATH TWIN CIRCULAR DISCS SPACED 5 1/2" BETWEEN INSIDE EDGES, R=4.37" at 75 psi WITH A GROSS WEIGHT OF 9000 lbs

MAXIMUM VERTICAL PRESSURE BENEATH A CIRCULAR DISC, R=4.60"-5.05" at 75 psi WITH A GROSS WEIGHT OF 5000 - 6000 lbs

DEPTH, Inches

VERTICAL PRESSURE, psi

VERTICAL PRESSURE VS DEPTH
(BOUSSINESQ EQUATION)

MAXIMUM VERTICAL PRESSURE BENEATH
TWIN CIRCULAR DISCS SPACED 5 1/2" BETWEEN
INSIDE EDGES, R = 4.37" at 75 psi WITH A
GROSS WEIGHT OF 9000 lbs

MAXIMUM VERTICAL PRESSURE BENEATH
A CIRCULAR DISC, R = 4.60" - 5.05" at 75 psi
WITH A GROSS WEIGHT OF 5000 - 6000 lbs

DEPTH, Inches

VERTICAL PRESSURE, psi

VERTICAL PRESSURE VS DEPTH
(BOUSSINESQ EQUATION)

MAXIMUM VERTICAL PRESSURE BENEATH
TWIN CIRCULAR DISCS SPACED 5 1/2" BETWEEN
INSIDE EDGES, R=4.37" at 75 psi WITH A
GROSS WEIGHT OF 9000 lbs

MAXIMUM VERTICAL PRESSURE BENEATH
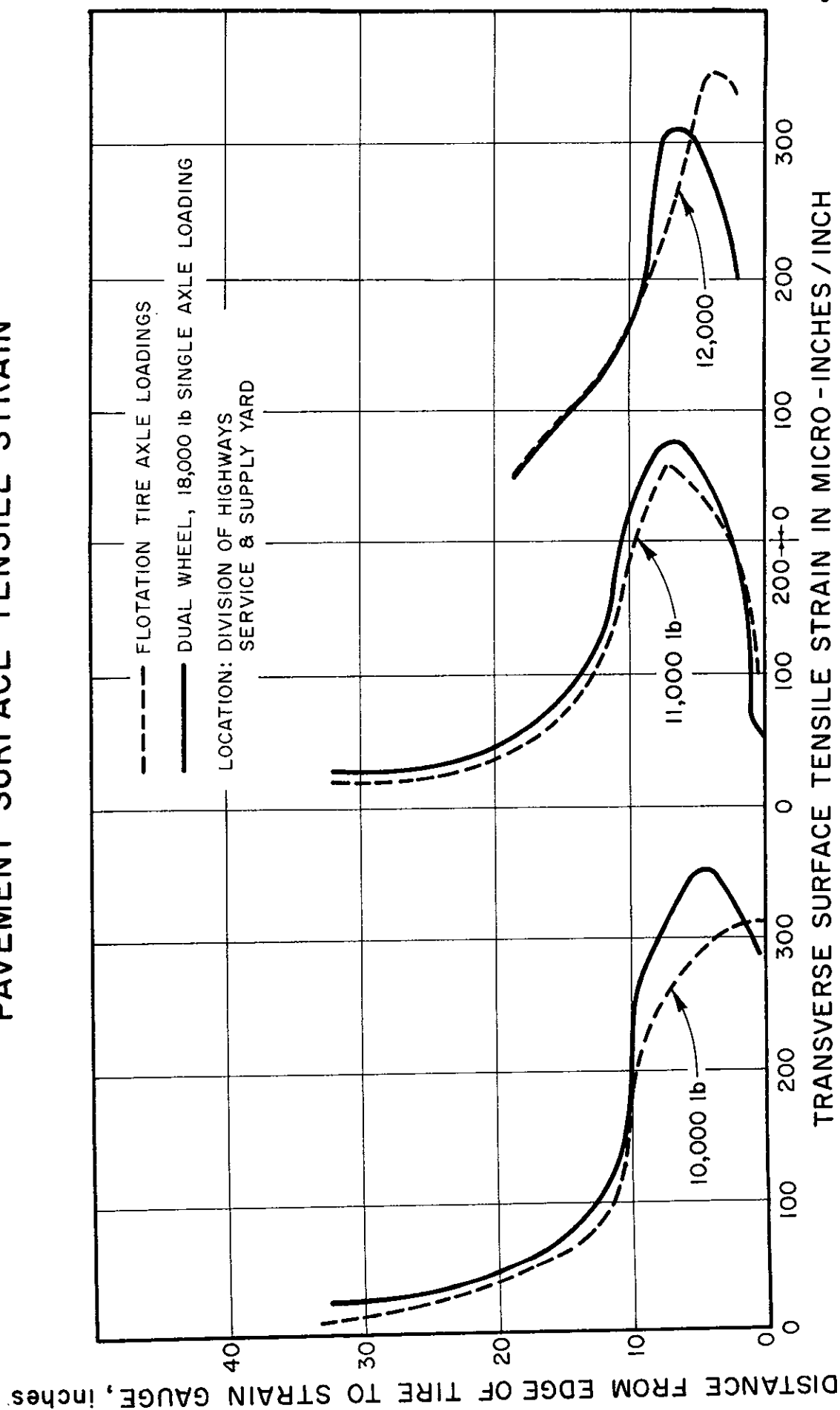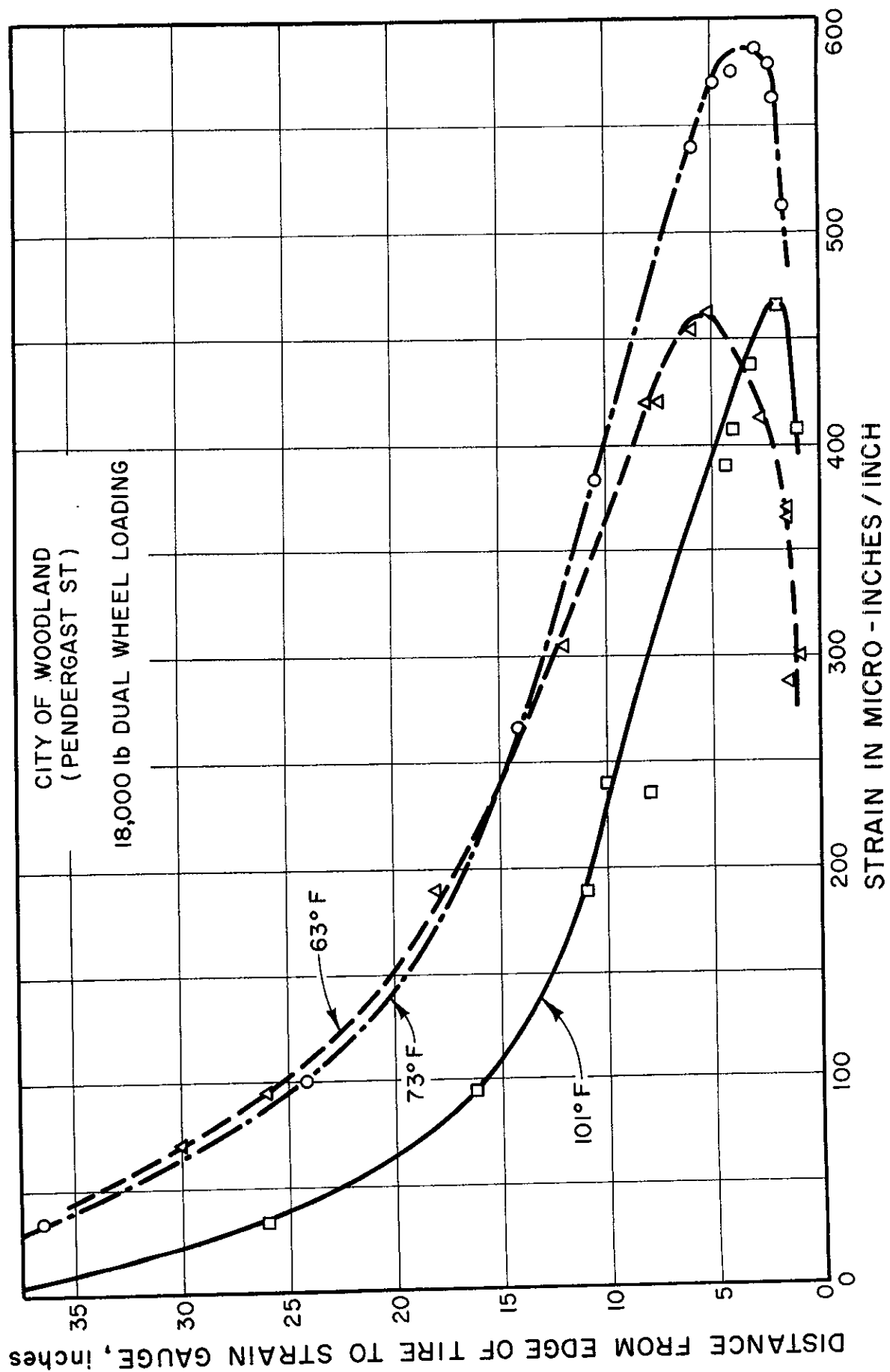A CIRCULAR DISC, R=4.60"-5.05" at 75 psi
WITH A GROSS WEIGHT OF 5000 - 6000 lbs

VERTICAL PRESSURE, psi

DEPTH, Inches

PAVEMENT SURFACE TENSILE STRAIN

VARIATION IN TRANSVERSE SURFACE STRAIN
INDUCED BY CHANGE OF PAVEMENT TEMPERATURE

CITY OF WOODLAND
(PENDERGAST ST)

18,000 lb DUAL WHEEL LOADING

63°F

73°F

101°F

STRAIN IN MICRO-INCHES / INCH

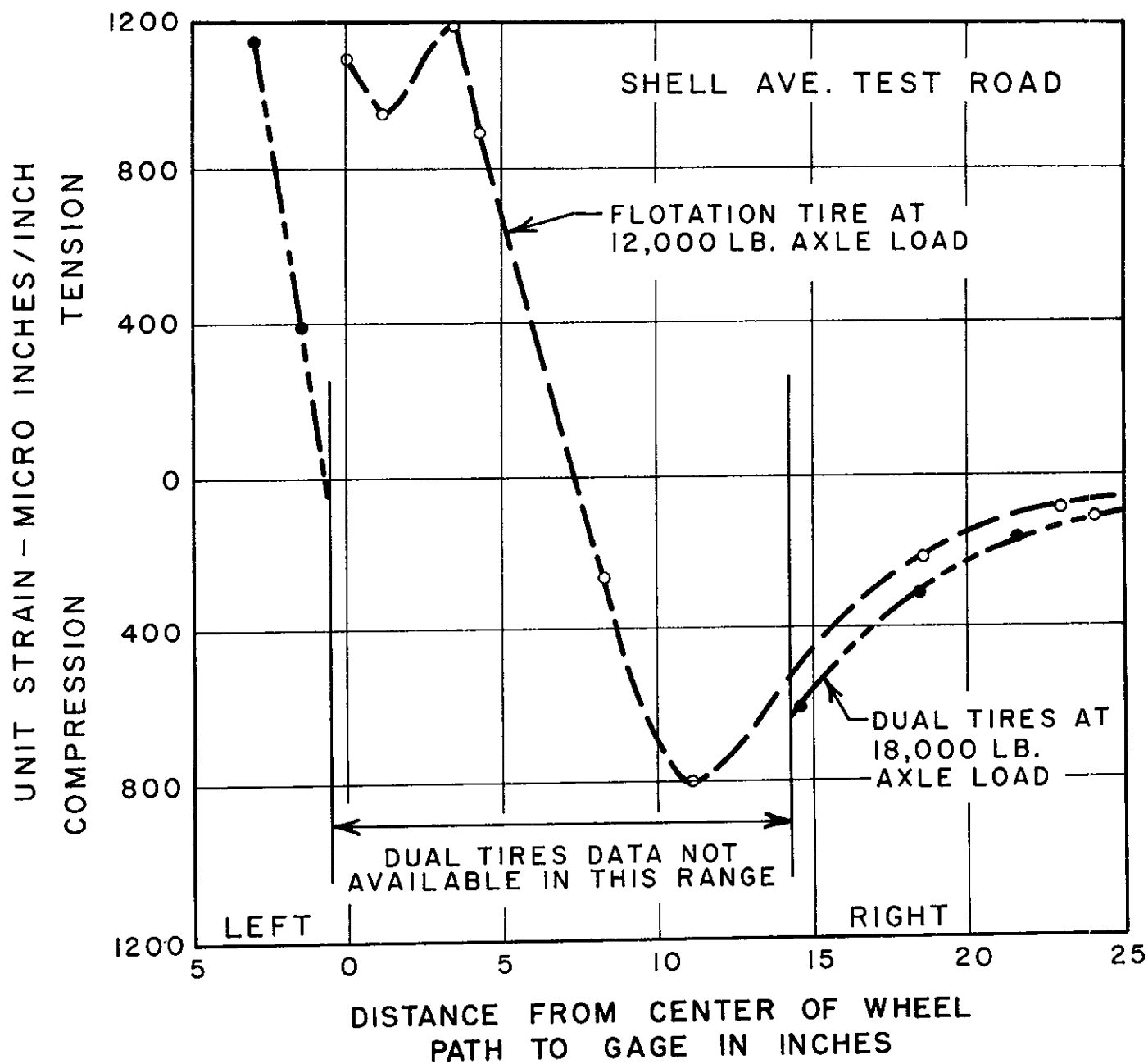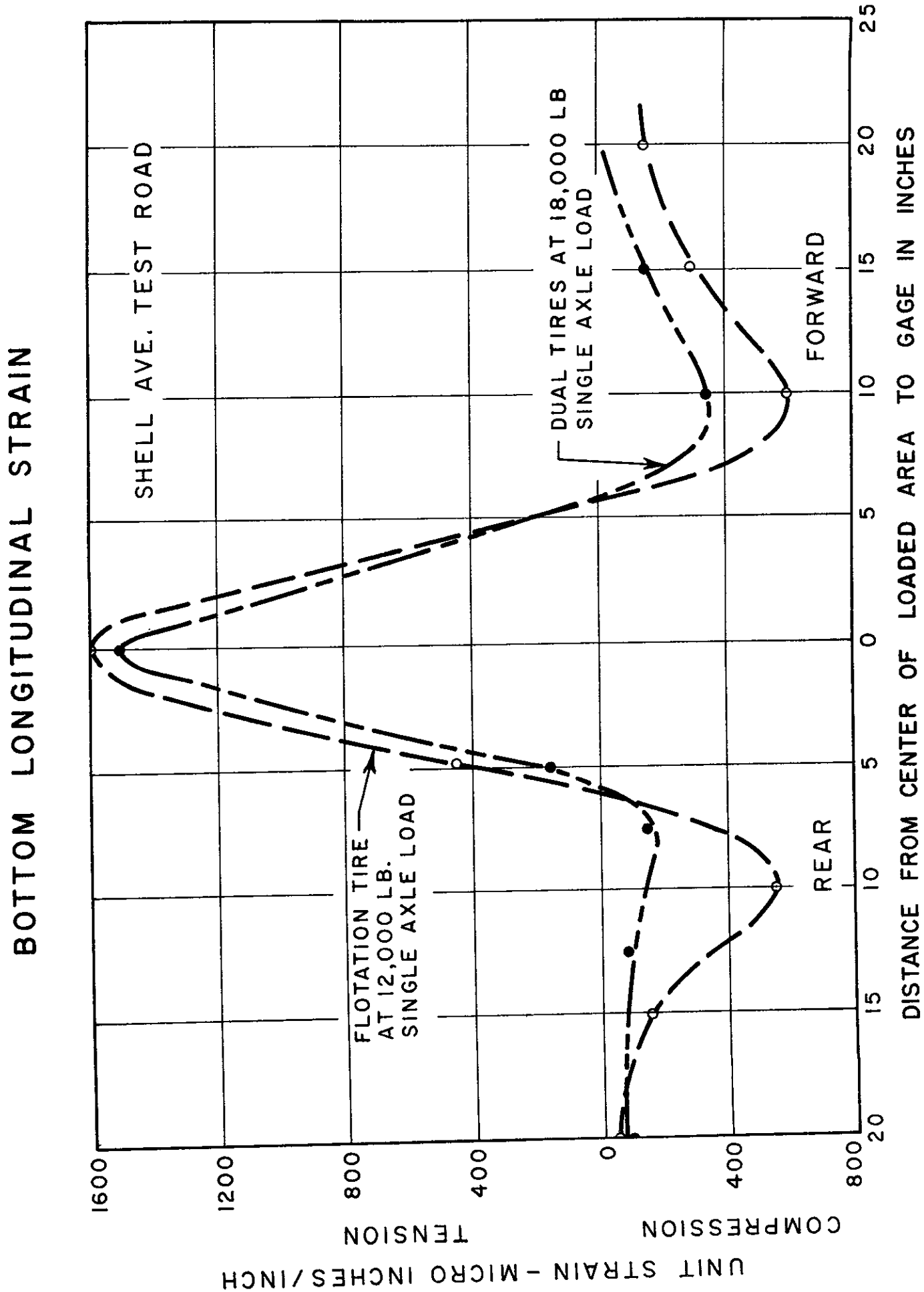DISTANCE FROM EDGE OF TIRE TO STRAIN GAUGE, inches

FLOTATION-DUAL TIRE SURFACE TENSILE STRAIN RATIOS VERSUS PAVEMENT TEMPERATURE

Figure 7

BOTTOM TRANSVERSE STRAIN

BOTTOM LONGITUDINAL STRAIN

SHELL AVE. TEST ROAD

DUAL TIRES AT 18,000 LB
SINGLE AXLE LOAD

FLOTATION TIRE
AT 12,000 LB.
SINGLE AXLE LOAD

FORWARD

REAR

DISTANCE FROM CENTER OF LOADED AREA TO GAGE IN INCHES

UNIT STRAIN — MICRO INCHES/INCH

TENSION

COMPRESSION
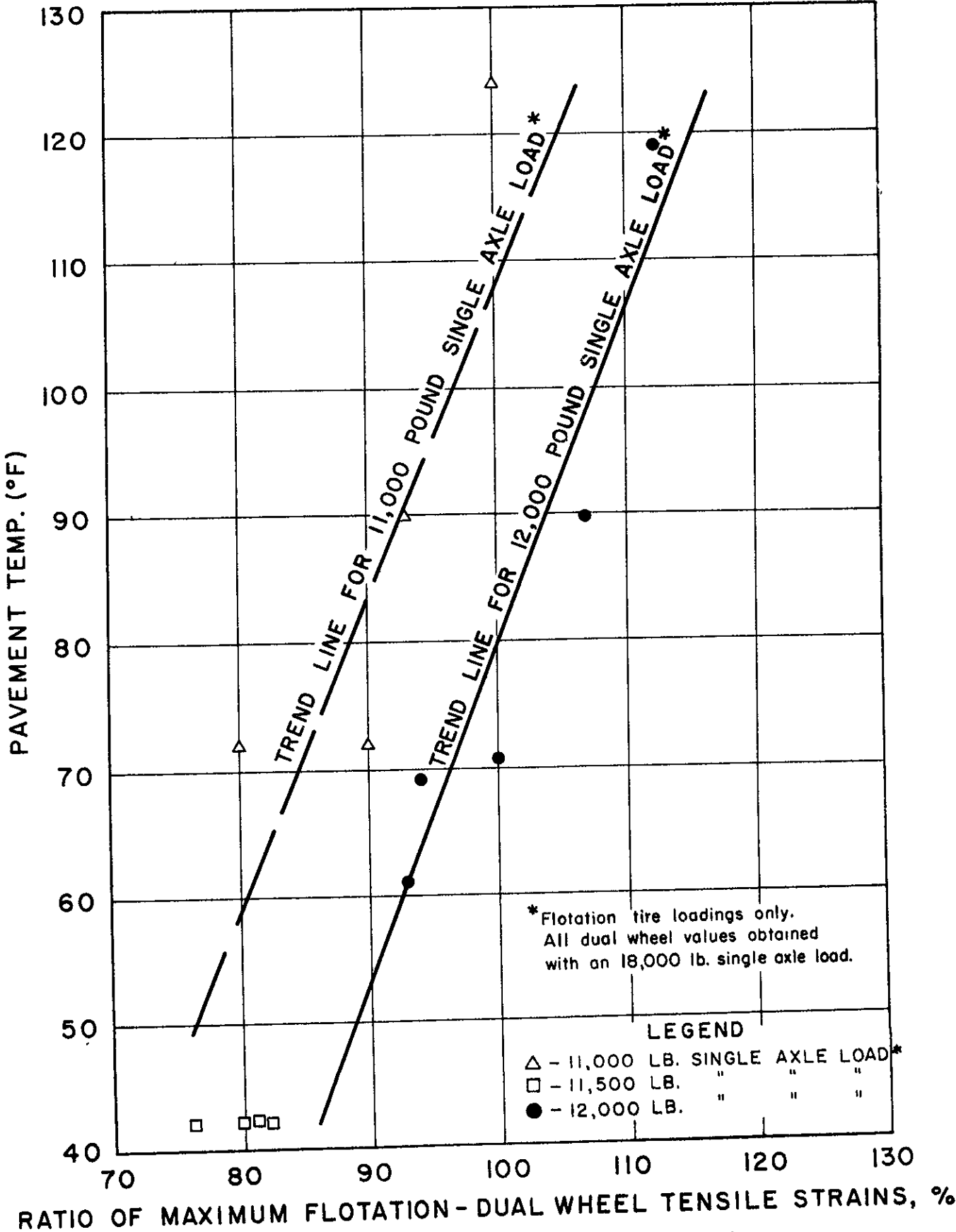
TRANSVERSE DEFLECTION PROFILE
LVDT GAGE UNIT

FLOTATION TIRE (12,000 LB. SINGLE AXLE LOAD)

DUAL TIRES (18,000 LB. SINGLE AXLE LOAD)

SHELL AVE. TEST ROAD

DEFLECTION (0.001")

DISTANCE FROM GAGE TO CENTER OF TIRE

(INCHES)
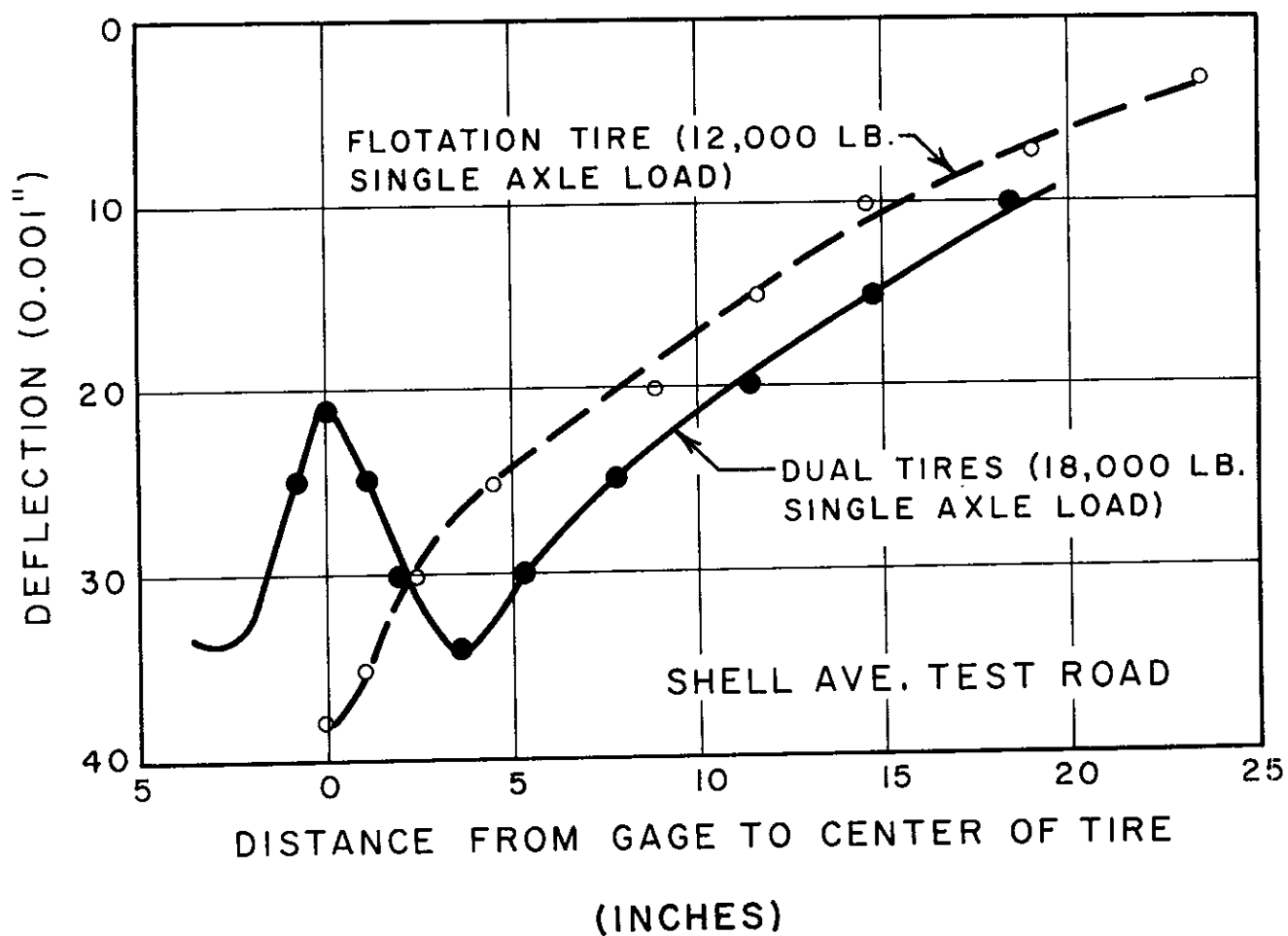
FLOTATION-DUAL TIRE DEFLECTION RATIOS
VERSUS FLOTATION SINGLE AXLE LOADING

PERCENT OF MAXIMUM DEFLECTION INDUCED BY
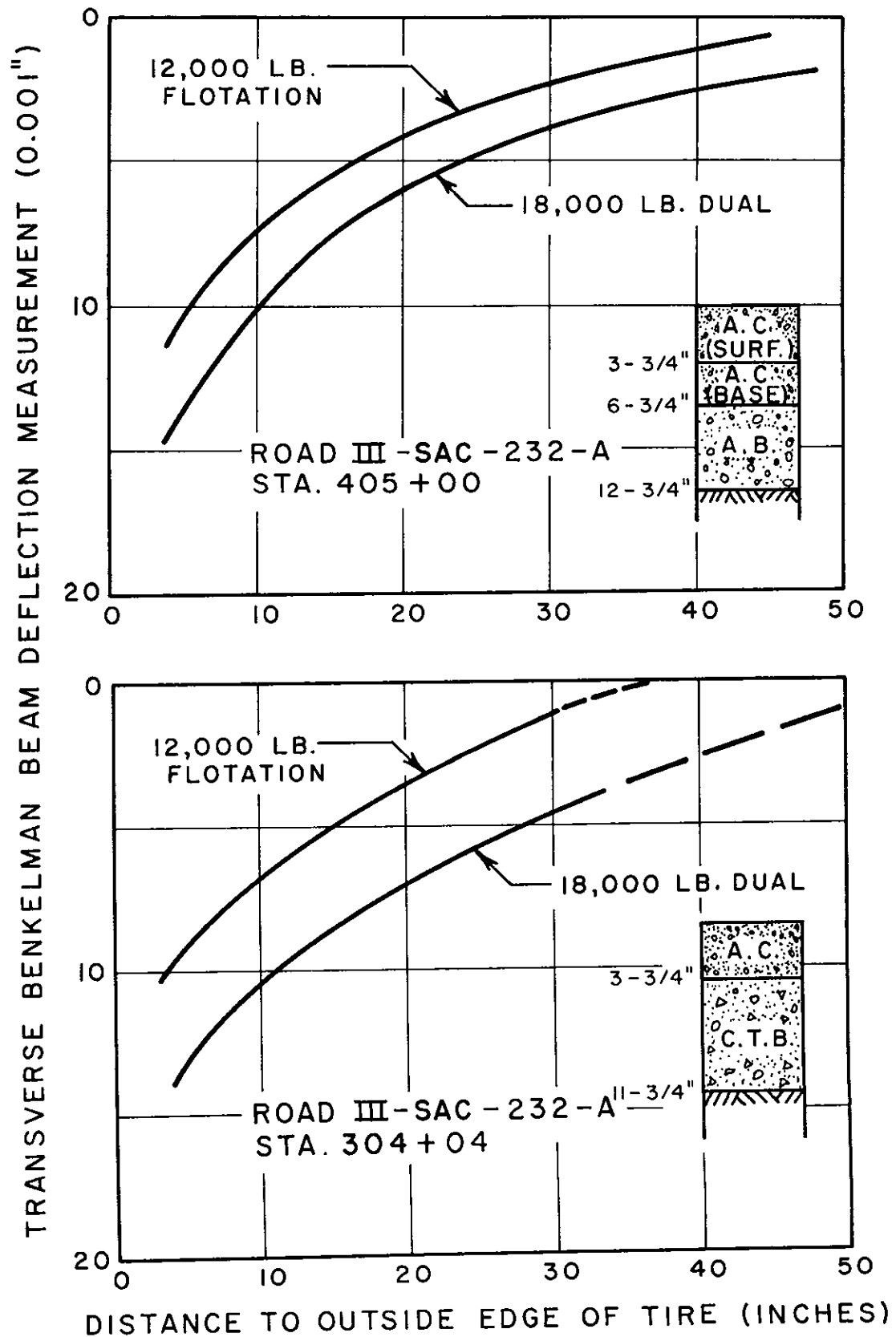18,000 LB. DUAL WHEEL LOAD
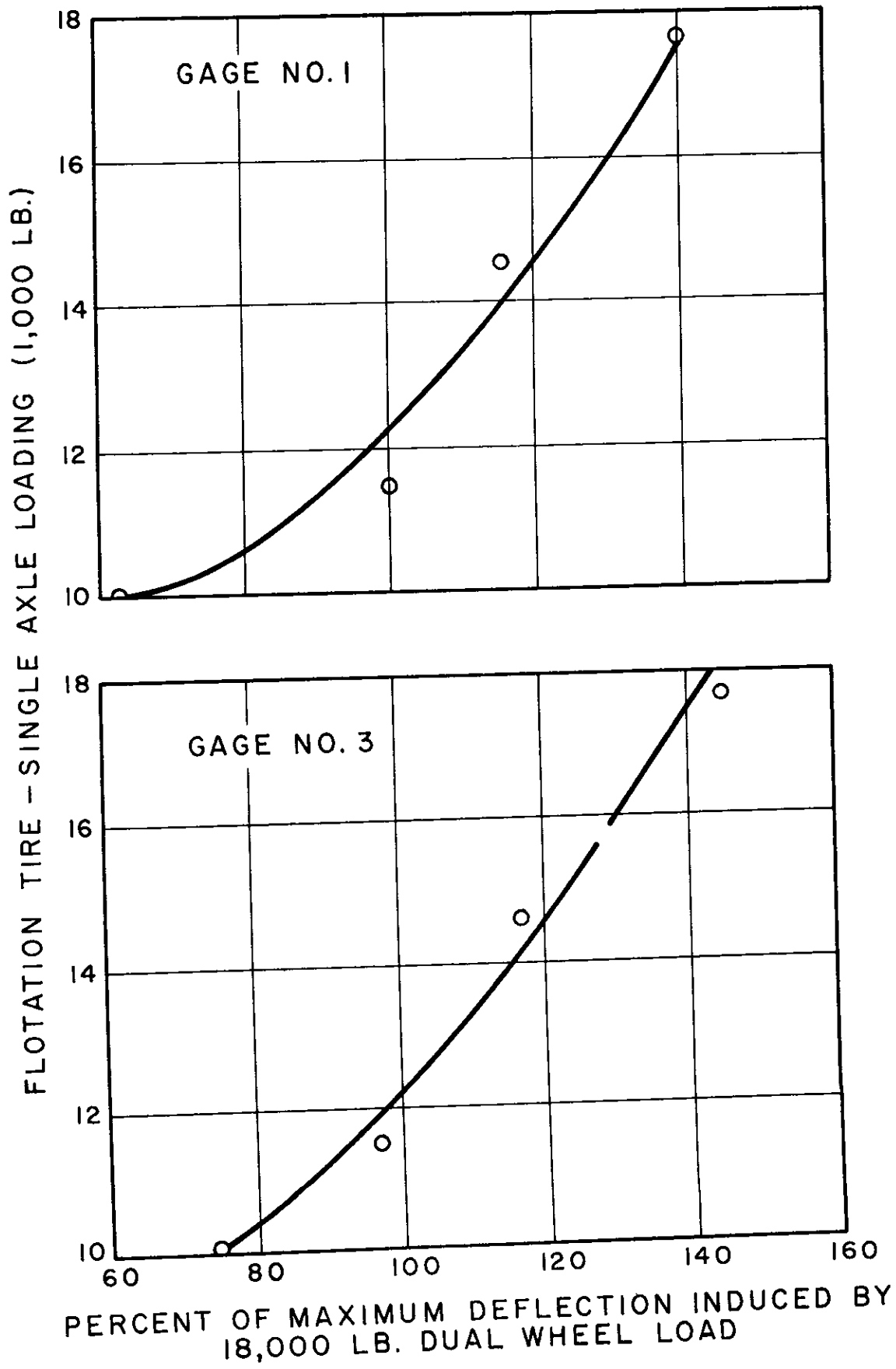
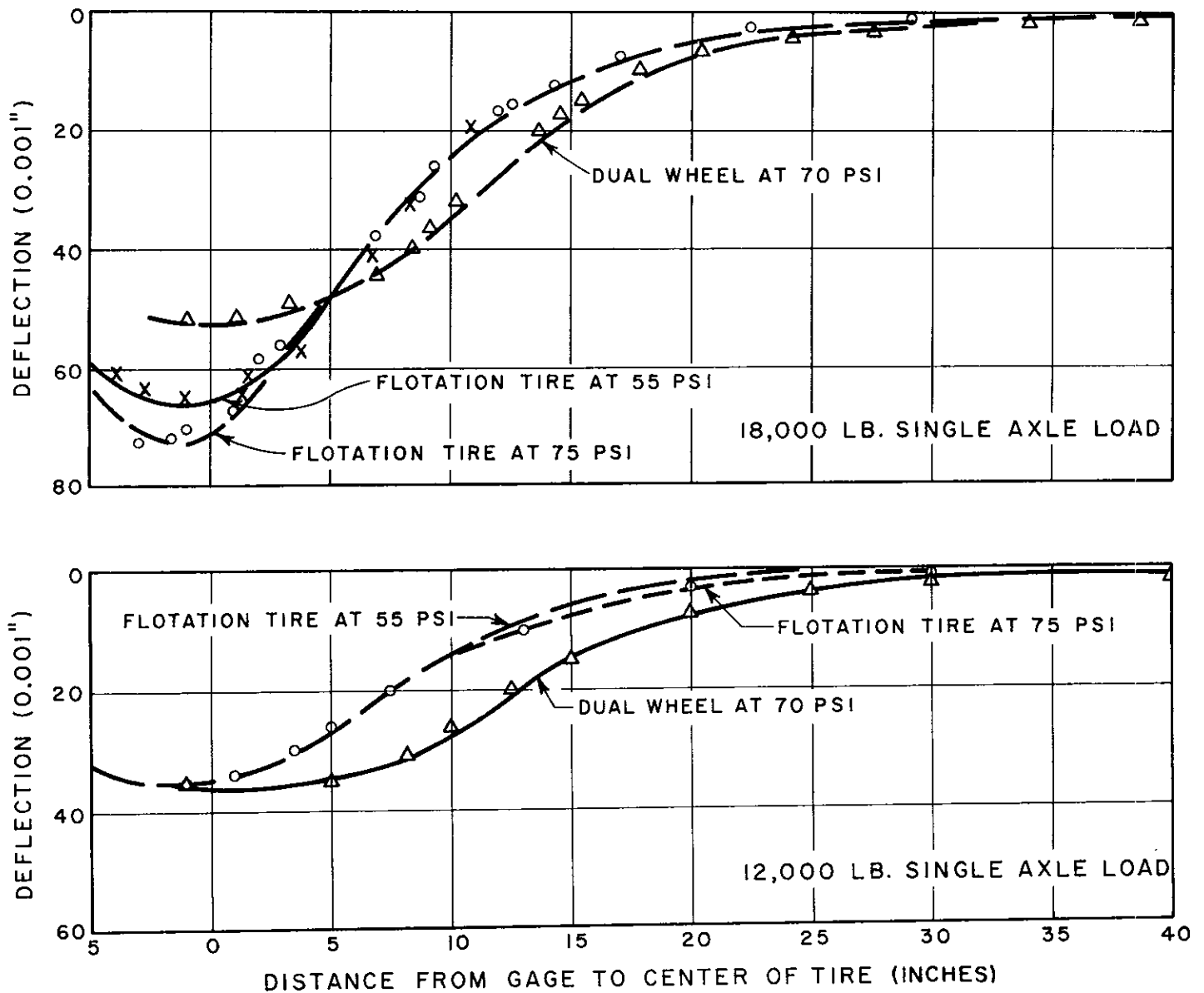# TRANSVERSE DEFLECTION PROFILE
(BENKELMAN BEAM)
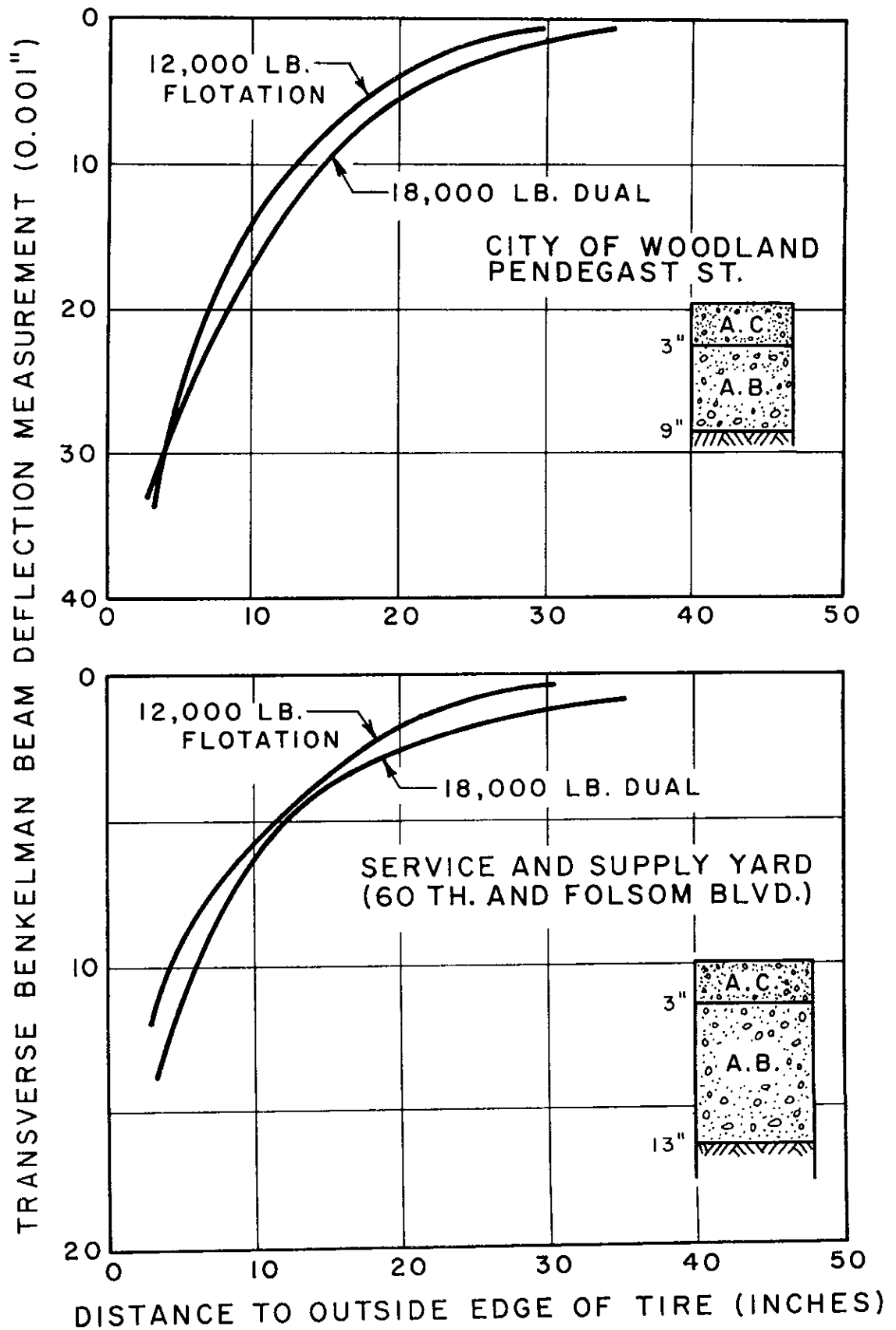
TRANSVERSE DEFLECTION PROFILE
(BENKELMAN BEAM)
ROAD III-SAC-232-A
STA 354+00
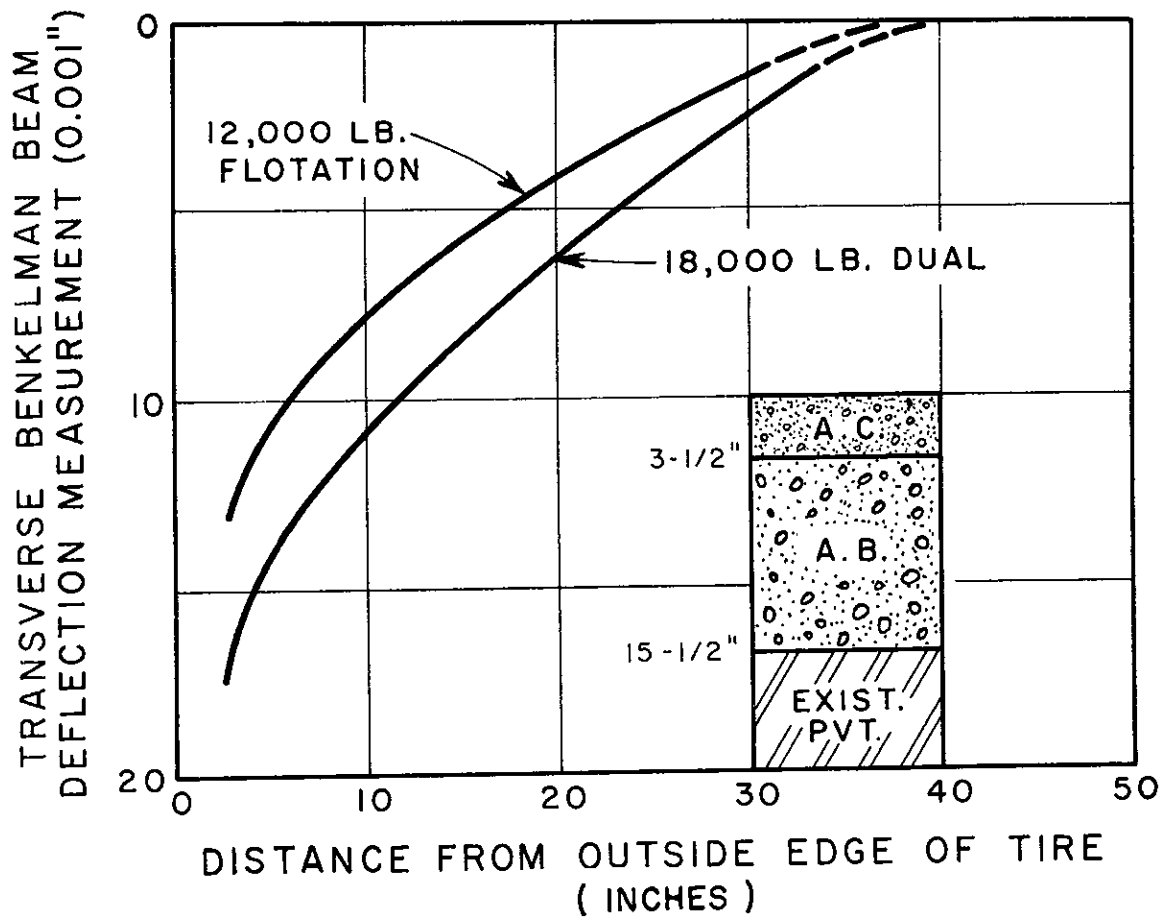
TRANSVERSE DEFLECTION PROFILE
(BENKELMAN BEAM)

EFFECT OF LOWERING FLOTATION TIRE PRESSURE
ON TRANSVERSE DEFLECTION PROFILE
LVDT GAGE UNIT

DUAL WHEEL AT 70 PSI

FLOTATION TIRE AT 55 PSI

FLOTATION TIRE AT 75 PSI

18,000 LB. SINGLE AXLE LOAD

DEFLECTION (0.001")

FLOTATION TIRE AT 55 PSI

FLOTATION TIRE AT 75 PSI

DUAL WHEEL AT 70 PSI

12,000 LB. SINGLE AXLE LOAD

DISTANCE FROM GAGE TO CENTER OF TIRE (INCHES)

EFFECT OF LOWERING FLOTATION TIRE PRESSURE ON LATERAL SURFACE TENSILE STRAIN

FLOTATION AND DUAL SINGLE AXLE LOADING = 18,000 LBS.
GAUGE NO. I - STATE FAIR GROUNDS

FLOTATION TIRE AT 55 PSI
FLOTATION TIRE AT 75 PSI
DUAL WHEEL AT 70 PSI

LATERAL SURFACE TENSILE STRAIN
(MICRO-INCHES/INCH)

DISTANCE FROM EDGE OF TIRE TO CENTER OF GAGE (INCHES)

EFFECT OF LOWERING FLOTATION TIRE PRESSURE ON LATERAL SURFACE TENSILE STRAIN

FLOTATION TIRE SINGLE AXLE LOADING = 12,000
DUAL WHEEL SINGLE AXLE LOADING = 18,000
GAUGE NO.1 STATE FAIR GROUNDS

FLOTATION TIRE AT 75 PSI

DUAL WHEEL AT 70 PSI

FLOTATION TIRE AT 55 PSI

EDGE OF TIRE TO GAGE IN INCHES

LATERAL SURFACE TENSILE STRAIN
(MICRO-INCHES / INCH)